DAVID W. TAYLOR NAVAL SHIP RESEARCH AND DEVELOPMENT CENTER

Bethesda, Md. 20084

SEAKEEPING EVALUATION OF THE JOINT ARMY/NAVY BALLOON TRANSPORT SYSTEM

by

David M. Gerzina

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SHIP PERFORMANCE DEPARTMEN

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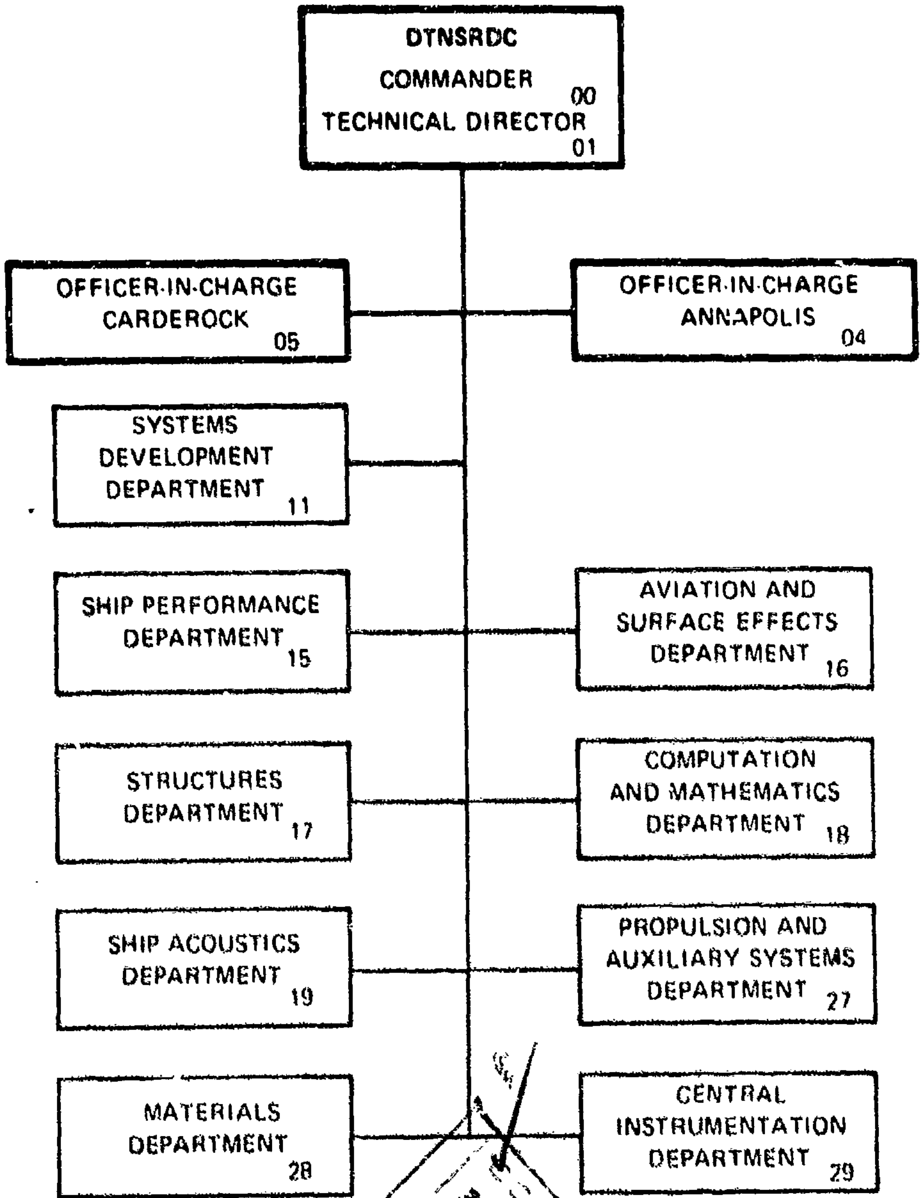

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During the evaluation of the joint Army/Navy Balloon Transport System conducted off of Green Beach, Ft. Story, Virginia, the David W. Taylor Naval Ship Research and Development Center (DTNSRDC) was tasked to measure ship motions on some of the vessels used in the operation. The vessels instrumented by DTNSRDC were the Army's BDL "LT. COL. JOHN U. D. PAGE," the LST 1180 "USS MANITOWOC," and two Navy LCUs of the 1610 series (1658 and 1659). Two principal configurations to remove Milvan containers from the vessels were

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investigated. The first was a ship to shore maneuver for which DTNSRDC instrumented the BDL and the LCU 1659. The second was a ship to lighter operation for which DTNSRDC recorded ship motions on the LST 1180 and the LCUs 1658 and 1659. Throughout the operations, the motions of the vessels investigated were, in general, rather small with the largest motions occurring aboard the LCUs when they were fendered off of the larger BDL and LST with Yokohama pneumatic fenders. The vessel motions were not the limiting factor in the operation of the balloon transfer system. Observations indicated that the ability to get the vessels into the proper position and weather operational limits of the balloon were of greater significance in the successful transfer of Milvan containers from the vessels.

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ABSTRACT

During the evaluation of the joint Army/Navy Balloon Transport System conducted off of Green Beach, Ft. Story, Virginia, the David W. Taylor Naval Ship Research and Development Center (DTNSRDC) was tasked to measure ship motions on some of the vessels used in the operation. The vessels instrumented by DTNSRDC were the Army's BDL "LT. COL. JOHN U. D. PAGE," the LST 1180 "USS MANITOWOC," and two Navy LCUs of the 1610 series (1658 and 1659). Two principal configurations to remove Milvan containers from the vessels were investigated. The first was a ship to shore maneuver for which DTNSRDC instrumented the BDL and the LCU 1659. The second was a ship to lighter operation for which DTNSRDC recorded ship motions on the LST 1180 and the LCUs 1658 and 1659. Throughout the operations, the motions of the vessels investigated were, in general, rather small with the largest motions occurring aboard the LCUs when they were fendered off of the larger BDL and LST with Yokohama pneumatic fenders. The vessel motions were not the limiting factor in the operation of the balloon transfer system. Observations indicated that the ability to get the vessels into the proper position and weather operational limits of the balloon were of greater significance in the successful transfer of Milvan containers from the vessels.

ADMINISTRATIVE INFORMATION

This work was authorized by the Naval Facilities Engineering Command Work Request WR 00090 and identified as Work Unit 1-1175-128.

INTRODUCTION

Investigations of the joint Army/Navy Balloon Transport System were conducted off of Green Beach, Ft. Story, Virginia, during the spring of 1976. These were to determine the feasibility of removing Milvan containers from ship to shore and from ship to lighter by means of a helium filled balloon.

The primary balloon system, see Figure 1, consists of a 500,000 cubic foot helium filled balloon, two yarders (diesel powered level wind winches) and a third winch, used in a manner similar to the yarders, for positioning the balloon. The yarders are used to control the elevation and lateral positioning of the balloon in a plane bounded by the distance between the yarders and the length of the cable on the yarder reels. The cable from the third winch is attached to a block through which passes a cable from one of the yarders and, with proper positioning of the "Flying Dutchman," enables the balloon to be moved transversely out of this plane.

During the operations one or both yarders were aboard the LCUs, and the winch of a warping tug, i.e., "Flying Dutchman," was used as the third point of control in the positioning of the balloon. Ship motion measurements were recorded by the Center on the LCUs which carried the yarders and aboard the container carrying vessels, the BDL and LST.* Seakeeping data were collected when the Milvan containers were being on or off loaded from the vessels. The results of this seakeeping information are presented in graphical and tabular form to aid in the overall evaluation of the feasibility of the balloon transport system.

VESSEL PARTICULARS, INSTRUMENTATION AND DATA ANALYSIS

BDL "LT. COL. JOHN U. D. PAGE"

The Army BDL is a 304.2-foot (92.72 metre) landing craft with a 65-foot (19.81 metre) beam, 7.5-foot (2.29 metre) draft, and a displacement of 2345 long tons (2383 tonnes). In the balloon transport system evaluation, the BDL was principally used as a container carrying vessel from which Milvan containers were removed in the ship to shore operation. During these operations the BDL was equipped with a Mark IV stable platform to measure the ship's motions. The Mark IV stable platform measures ship pitch, roll, and with three stabilized axis accelerometers yields the vertical, transverse, and

*Naval Ship Engineering Center, Norfolk, was responsible for motion measurements aboard the warping tug and the Waverider buoy.

longitudinal accelerations at the point of installation. The installation location of the Mark IV aboard the BDL was 1.5 feet (.46 metres) to port of centerline at amidships and two levels below the main deck. Thus accelerations measured at this point (near the ship's center of gravity) could be converted to displacements representing heave, sway and surge.

LST 1180 "USS MANITOWOC"

The LST 1180 is of the "Newport Class" and has a full load displacement of 8342 long tons (8476 tonnes). Its length overall is 522.3 feet (159.20 metres) with a beam of 69.5 feet (21.18 metres) and a draft of 15 feet (4.57 metres). The LST 1180 was used in the ship to lighter operation with the LCU 1658 tied alongside. A DTNSRDC strap down motion package was used aboard the LCU 1658 with power for the electronic transducers coming from the equipment used aboard the LST. This power requirement limited the positioning of the electronic equipment aboard the LST to an area where a cable run to the LCU 1658 could be made. An area for the Mark IV stable platform location was selected at Frame 235, 8.5 feet (2.59 metres) below the main deck and 12 feet (3.66 metres) starboard of centerline in the PASSAGE AND CONFLAGRATION STATION No. 2 (2-235-1). This is a small compartment one level below the main deck, aft of the tank turntable and helicopter landing pad. The use of this location did not permit heave, surge and sway measurements of the ship's center of gravity. However, it did allow measurements of the vertical, transverse and longitudinal accelerations of a point near the Milvan container off and on loading operations, and enabled the necessary cable run for the LCU 1658.

LCU 1658 AND 1659

The LCU 1658 and 1659 are of the 1610 series with a length overall of 134.9 feet (41.12 metres), a beam of 29 feet (8.84 metres) and a draft of 6.1 feet (1.86 metres). The LCUs of the 1610 series have a light displacement of 200 long tons (203.2 tonnes) and a full load displacement of 375 long tons (381.0 tonnes).

The LCU 1659 was instrumented with a Humphrey stable platform which is equipped with a vertically stabilized directional gyroscope for pitch and roll measurements and three axis accelerometers. During the first stages

of the operation these accelerometers failed and were replaced by a Donner double integrating accelerometer for the heave displacement signal and two hard mounted accelerometers for surge and sway acceleration signals. The surge and sway accelerometers were part of the DTNSRDC strap down package which was later moved to the LCU 1658 for the ship to lighter operations. The electronic transducers were positioned near the center of gravity of the LCU 1659 6.8 feet (2.07 metres) below the main deck, 11 feet (3.35 metres) aft of bulkhead 40 and on the centerline.

The LCU 1658 was instrumented with the DTNSRDC strap down motion package which consists of a Honeywell gyroscope to measure pitch and roll and three hard mounted Donner accelerometers to measure vertical, transverse, and longitudinal accelerations. Due to a limited length of transducer cable, the location of the DTNSRDC strap down package was dependent upon the location along the length of the LST at which the LCU was tied. For Runs 11 through 14 the LCU 1658 was positioned along the port side of the LST with its midships centered on Frame 184 of the LST and the location of the strap down package aboard the LCU was on the centerline of the main deck at Frame 15. For Run 15 the LCU 1658 was positioned along the starboard side of the LST, again with its midships centered about Frame 184 and the strap down motion package was relocated on the centerline of the main deck at Frame 55.

Throughout the duration of the operations the sea state was measured by means of a Datawell Waverider buoy provided by NAVSEC, Norfolk.

DATA REDUCTION TECHNIQUE

The data signals were recorded on visual direct writing oscillograph units and analog tape recorders during the investigations. The analog tapes were later digitized and analyzed at the Center on an Interdata computer. The calibrations were entered into the computer as engineering units per volt, and as the data were digitized, preliminary analyses were performed to give the mean and root mean square values for each channel.

Two computer passes were made on the data. During the first pass the mean value of the signal was computed along with maximum and minimum values from the digitized time domain data. During the second pass the mean is

subtracted on a point by point basis from the data, while a FAST FOURIER TRANSFORM spectral analysis is performed on the data to yield the significant values.

TRIAL CONFIGURATIONS

In the evaluation of the balloon transport system there were two principal operational configurations. These were the ship to shore and the ship to lighter configurations. The ship to shore operation involved three vessels as indicated in the upper half of Figure 2, i.e., the BDL, the LCU 1659 and the Warping Tug No. 34. In this operational mode, the BDL was moored and used as a container carrying vessel. The LCU 1659 was tied to the starboard side of the BDL and equipped with a yarder to serve as one point of control for the balloon. The second yarder was on the beach and the warping tug (equipped with winch and block) served as a "Flying Dutchman." During the ship to shore operations the LCU 1659 was tied to the starboard side of the BDL with its bow directed toward the BDL's stern. The LCU was positioned forward of the BDL's midships and fendered off of the BDL with two Yokohama fenders. As seen in the upper half of Figure 2, the principal direction of the swell component of wave height during these operations was off of the BDL's starboard bow and the LCU's port stern. As indicated, the apparent direction of the swell varied relative to vessels. This was due to the shifting of mooring lines and changes in the vessels' position. The relative positioning of the vessels involved in the operation is critical to the proper maneuverabi...y of the balloon in trying to remove Milvan containers.

In the ship to lighter operations, both yarders were aboard LCUs and all three points of control were attached directly to the balloon tethering line as indicated in the lower half of Figure 2 and in Figure 3. The first attempt in the ship to lighter operation involved the BDL, LCUs 1656 and 1659 and the warping tug. During this brief attempt to move containers from ship to lighter, the mooring of the BDL shifted and no containers were off loaded (Run No. 10). The remaining runs were conducted using the LST 1180, LCUs 1658 and 1659, and the warping tug. As indicated in Figure 3, the relative mooring configuration between the vessels changed; this was

principally the result of the change in current direction and an attempt to keep the LCU 1658 on the lee side of the LST. As seen for Runs 11 through 14, the LCU was fendered off the port side of the LST with its bow directed toward the LST stern. The midship position of the LCU 1658 was located about Frame 184 of the LST with the LCU 1659 seaward of the LST and the warping tug off the LST's stern. The vessel configuration for Run 1[illegible] was similar to that for the other ship to lighter operations with the exception of changing sides of the LST and the wind driven waves being 180 degrees out from the swell.

RESULTS AND DISCUSSION

Presented in Table 1 are the single amplitude significant values for the ship motion data recorded aboard the BDL and LCU 1659 in the ship to shore and ship to lighter configurations. In addition to the single amplitude significant values for each data channel, the date, run number, time of run and significant wave height, $(\tilde{\zeta}_w)_{1/3}$, are given. From this information the wave spectra measured during each run can be selected from Figures 4 through 6. In those instances where data were unobtainable due to transducer failure, electronic malfunction, technical difficulties in general, etc., the word "out" is used. The (*) for Run No. 5 is to indicate that the data for the LCU 1659 was not recorded simultaneously with that of the BDL. The time of day for Run 5 on the LCU was from 1340 to 1405. The sea state condition during which each of the vessel's data were being recorded for Run 5 was the same; however, the LCU 1659 was being repositioned (moved approximately 30 feet farther forward along the length of the BDL) while its motions were recorded.

In a similar format, Table 2 presents the single amplitude maximum values recorded for the BDL and LCU 1659. The maximum values for the displacement signals obtained from double integration of acceleration signals are unobtainable, since the maximum values are obtained from the time domain analysis and for these channels this would be in terms of g's, not feet.

Tables 3 and 4 present the single amplitude significant and maximum values recorded aboard the LST 1180 and LCUs 1658 and 1659 during the ship to lighter operations. The format used in presenting the data is the same as for Tables

1 and 2. The wave height spectra recorded for each of the runs are given in Figures 6 and 7.

As indicated in Figures 4 through 7, the significant wave heights measured were of the same magnitude for most of the runs in both operating conditions. The spectra presented are point spectra and thus reflect the total wave energy regardless of direction. The swell component that existed off of Green Beach was generally directed straight onto the shore and was the principal source of wave energy, as indicated in the various spectra as the modal period (period of maximum energy), with the wind-generated waves having no noticeably different direction except as previously indicated for Run No. 15. The direction of the principal swell component, as indicated in Figures 2 and 3, was derived visually, and in many instances was difficult to determine due to the small wave height and superimposed wind waves.

CONCLUDING REMARKS

As seen from the tables of single amplitude significant and the maximum values presented, the motions of the vessels were, in general, relatively small and did not inhibit the balloon transport operations. The largest motions recorded were for roll on board the LCUs when they were fendered off the larger vessels with Yokohama fenders. The motions of the LCUs were aggravated by the stretch of the nylon lines and the resilience of the Yokohama pneumatic fenders.

Observations of the overall operation indicated that the ability to get the vessels into the proper position and weather operational limits of the balloon are of greater significance in the successful transfer of Milvan containers than are the absolute motions of the vessels involved.

TABLE 1 - SINGLE AMPLITUDE SIGNIFICANT VALUES FOR THE BDL AND LCU 1659
IN THE SHIP TO SHORE AND SHIP TO LIGHTER CONFIGURATIONS

Ship to Shore Configuration					Single Amplitude Significant Values									
					BDL					LCU 1659				
Date	Run No.	Time of Day Start	Time of Day Finish	Sig. Wave Ht. feet (metre)	Pitch deg	Roll deg	Heave feet (metre)	Sway feet (metre)	Surge feet (metre)	Pitch deg	Roll deg	Heave feet (metre)	Sway feet (metre)	Surge feet (metre)
3/14	2	1602	1639	1.86 (.567)	.22	.44	.12 (.037)	.22 (.067)	.25 (.076)	1.09	1.86	out	out	out
3/25	3	1227	1302	1.50 (.457)	.09	.14	.01 (.003)	.00 (.000)	.08 (.024)	.57	.94	.32 (.098)	out	out
	4	1516	1702	1.94 (.591)	.20	.45	.15 (.046)	.28 (.085)	.01 (.003)	1.95	.84	.77 (.235)	out	out
3/23	5*	1213	1318	2.75 (.838)	.26	.98	.17 (.052)	.28 (.085)	.00 (.000)	1.20	5.37	.87 (.255)	1.54 (.469)	1.58 (.482)
	6	1405	1558	2.75 (.838)	.17	.57	.11 (.034)	.11 (.034)	.00 (.000)	1.17	3.71	.72 (.219)	1.22 (.372)	1.22 (.372)
	7	1604	1621	2.60 (.792)	.17	.38	.09 (.027)	.08 (.024)	.00 (.000)	1.05	2.91	.62 (.189)	.87 (.265)	.94 (.287)
3/24	8	1012	1220	2.14 (.652)	[illegible]	.84	.20 (.061)	.39 (.119)	.00 (.000)	.91	2.24	.79 (.241)	1.52 (.463)	1.22 (.372)
	9	1349	1406	2.91 (.887)	.22	.62	.12 (.037)	.11 (.034)	.00 (.000)	1.14	3.95	.85 (.259)	1.21 (.369)	1.68 (.512)
Ship to Lighter Configuration														
3/26	10	1344	1348	2.08 (.634)	.32	1.17	.66 (.201)	1.53 (.466)	.48 (.146)	.95	1.23	.87 (.265)	.18 (.055)	1.79 (.546)

*LCU 1659 run time of day 1340 to 1405.

TABLE 2 - SINGLE AMPLITUDE MAXIMUM VALUES FOR THE BDL AND LCU 1659
IN THE SHIP TO SHORE AND SHIP TO LIGHTER CONFIGURATIONS

Ship to Shore Configuration					Single Amplitude Maximum Values				
					BDL		LCU 1659		
Date	Run No.	Time of Day Start	Time of Day Finish	Sig. Wave Ht. feet (metre)	Pitch deg	Roll deg	Pitch deg	Roll deg	Heave feet (metre)
3/14	2	1602	1639	1.86 (.567)	.71	.79	out	out	out
3/15	3	1227	1302	1.50 (.457)	.16	.25	.82	1.05	.52 (.158)
	4	1616	1702	1.94 (.591)	.34	1.01	3.39	1.94	1.34 (.408)
3/23	5*	1213	1318	2.75 (.838)	.48	1.92	2.20	9.63	1.60 (.488)
	6	1405	1558	2.75 (.838)	.37	1.38	2.50	6.94	1.53 (.466)
	7	1604	1621	2.60 (.792)	.27	.69	1.94	4.55	1.07 (.376)
3/24	8	1012	1220	2.14 (.652)	.52	1.96	2.15	4.82	1.81 (.552)
	9	1349	1406	2.91 (.887)	.42	1.06	1.95	7.67	1.49 (.454)
Ship to Lighter Configuration									
3/26	10	1344	1348	2.08 (.634)	.43	1.38	1.35	1.98	1.23 (.375)

*LCU 1659 run time of day 1340 to 1405.

TABLE 3 - SINGLE AMPLITUDE SIGNIFICANT VALUES FOR THE LST 1180 AND LCUs 1658 AND 1659 IN THE SHIP TO LIGHTER CONFIGURATION

Ship to Lighter Configuration					Single Amplitude Significant Values													
					LST 1180					LCU 1659			LCU 1658					
Date	Run No.	Time of Day Start	Time of Day Finish	Sig. Wave Ht. feet (metre)	Pitch deg	Roll deg	Vert Disp feet (metre)	Long Disp feet (metre)	Trans Disp feet (metre)	Pitch deg	Roll deg	Heave feet (metre)	Pitch deg	Roll deg	Vert Disp feet (metre)	Long Disp feet (metre)	Trans Disp feet (metre)
3/29	11	0950	1050	1.28 (.390)	.10	1.06	.62 (.189)	.00 (.000)	.40 (.122)	.45	.74	.48 (.146)	.24	1.00	.44 (.134)	.56 (1.71)	out
	12	1102	1150	1.19 (.363)	.08	1.14	.67 (.204)	.09 (.027)	.41 (.125)	.42	.59	.47 (.143)	.27	1.01	.47 (.143)	.67 (.204)	out
	13	1223	1333	1.35 (.411)	.12	1.38	.67 (.204)	.09 (.027)	.41 (.125)	.46	.78	.46 (.140)	.19	1.01	.43 (.131)	.61 (.186)	out
	14	1340	1402	1.47 (.448)	.33	1.14	.67 (.204)	.00 (.000)	.42 (.128)	.50	1.10	.50 (.152)	.24	1.42	.44 (.134)	.47 (1.43)	out
4/2	15	0857	1037	2.45 (.747)	.21	2.01	.95 (.290)	.00 (.000)	.94 (.287)	.90	1.54	.95 (.290)	.44	3.15	.86 (.262)	.82 (.250)	out

TABLE 4 - SINGLE AMPLITUDE MAXIMUM VALUES FOR THE LST 1180 AND LCUs 1658 AND 1659 IN THE SHIP TO LIGHTER CONFIGURATION

Ship to Lighter Configuration					Single Amplitude Maximum Values							
					LST 1180		LCU 1659			LCU 1658	
Date	Run No.	Time of Day Start	Time of Day Finish	Sig. Wave Ht. feet (metre)	Pitch deg	Roll deg	Pitch deg	Roll deg	Heave feet (metre)	Pitch deg	Roll deg
3/29	11	0950	1050	1.28 (.390)	.20	2.30	1.00	2.25	.88 (.268)	.84	2.83
	12	1102	1150	1.19 (.363)	.18	2.21	1.05	1.43	.76 (.233)	.69	2.37
	13	1223	1333	1.35 (.411)	.34	2.58	.94	1.89	.84 (.256)	.43	2.24
	14	1340	1402	1.47 (.448)	.60	1.87	.98	2.39	.70 (.213)	.57	2.94
4/2	15	0857	1037	2.45 (.747)	.45	3.37	2.06	4.40	1.86 (.567)	.88	6.87

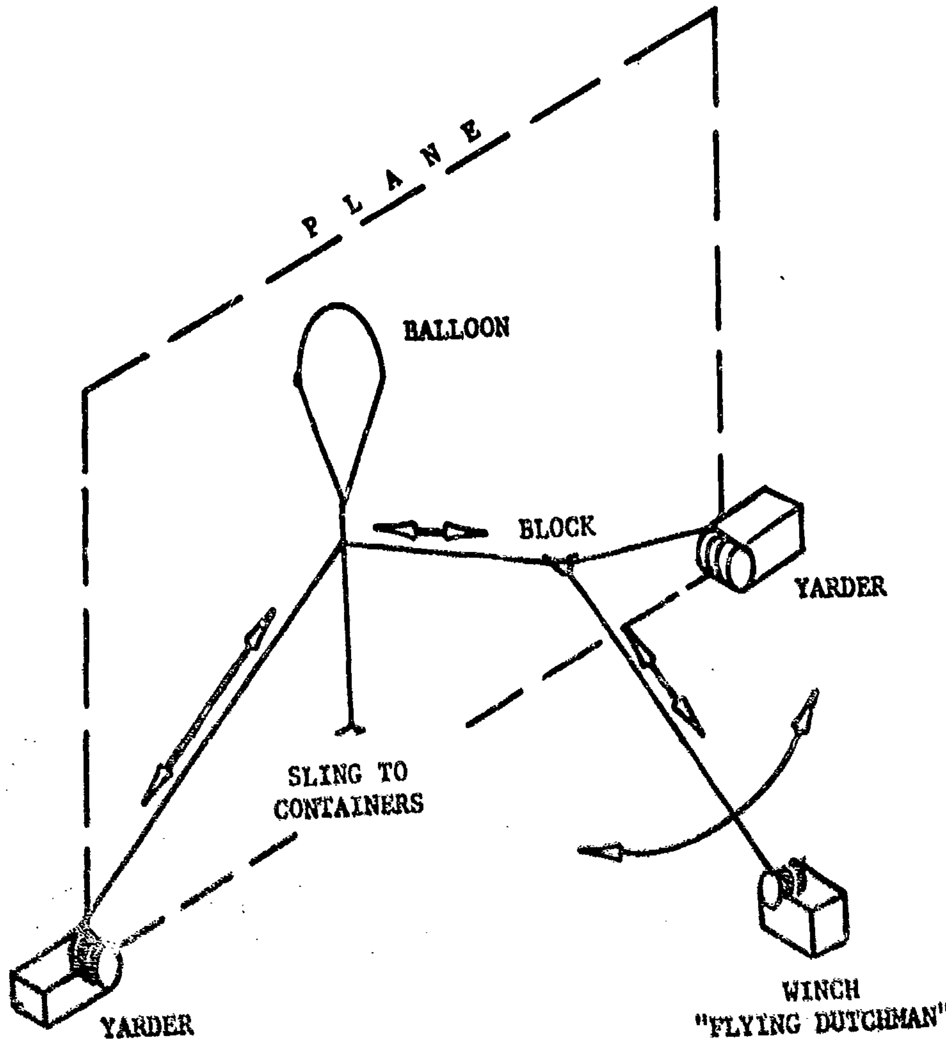


Figure 1 - Illustration of Primary Balloon System

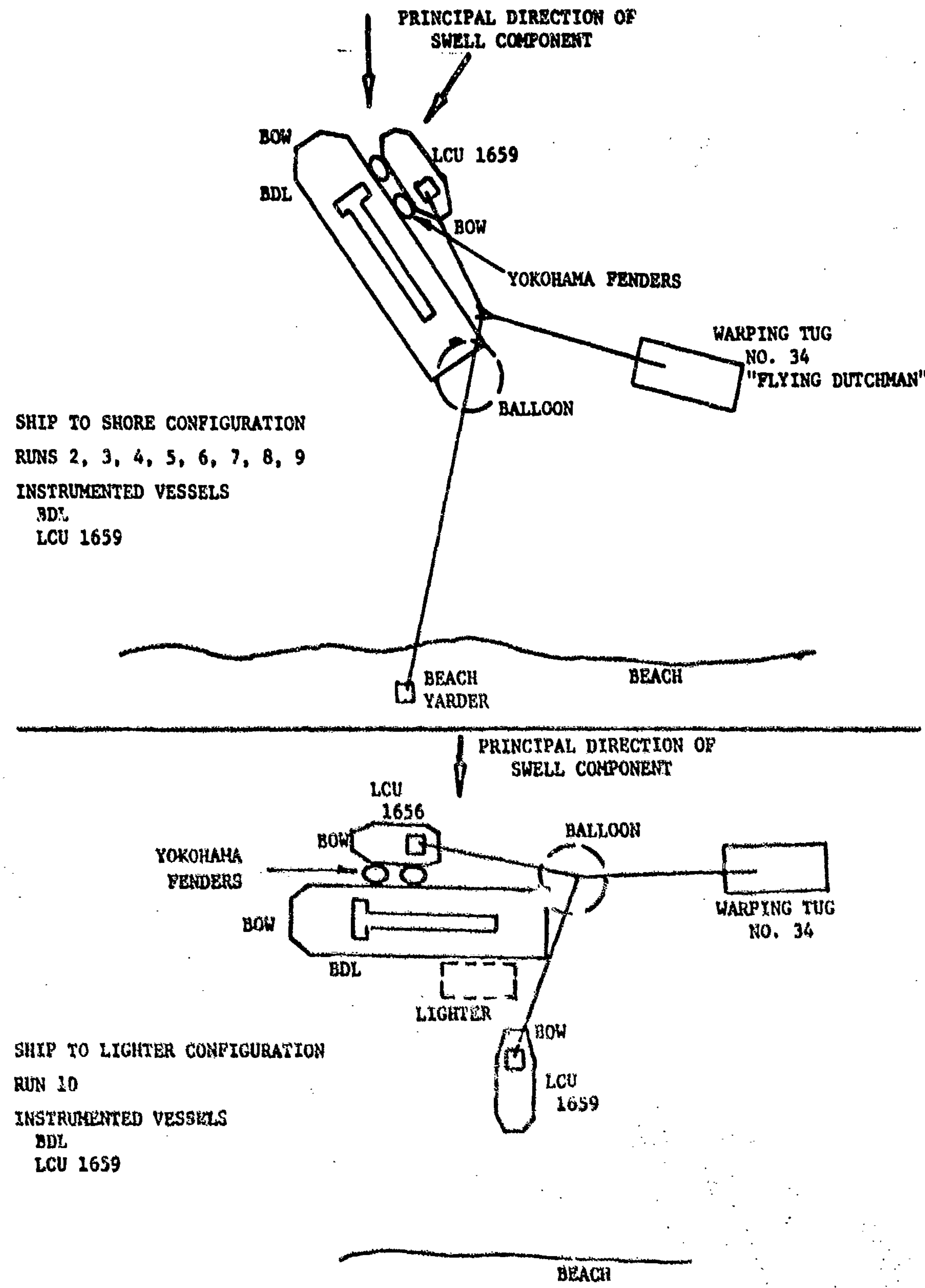
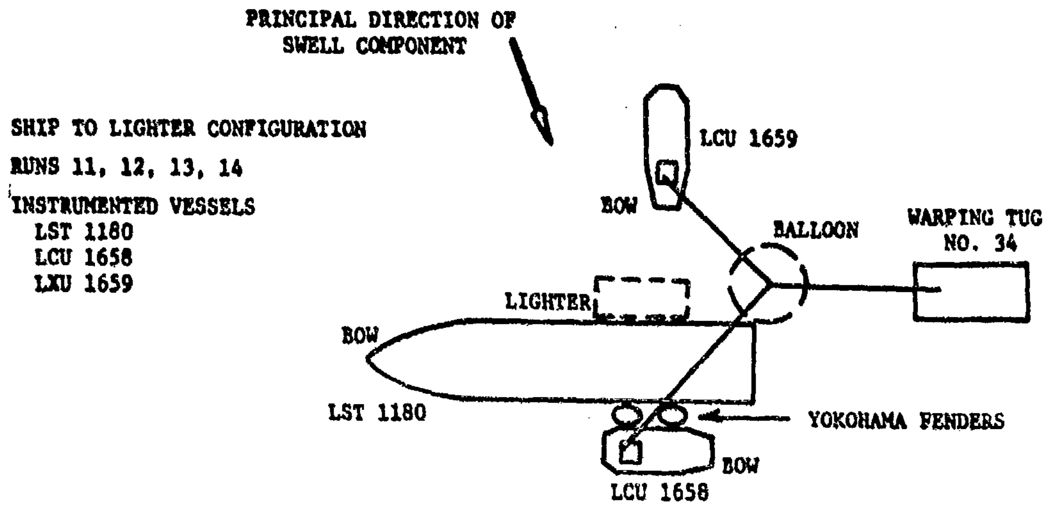


Figure 2 - Ship to Shore and Ship to Lighter Configurations in which the BDL and LCU 1659 were Instrumented



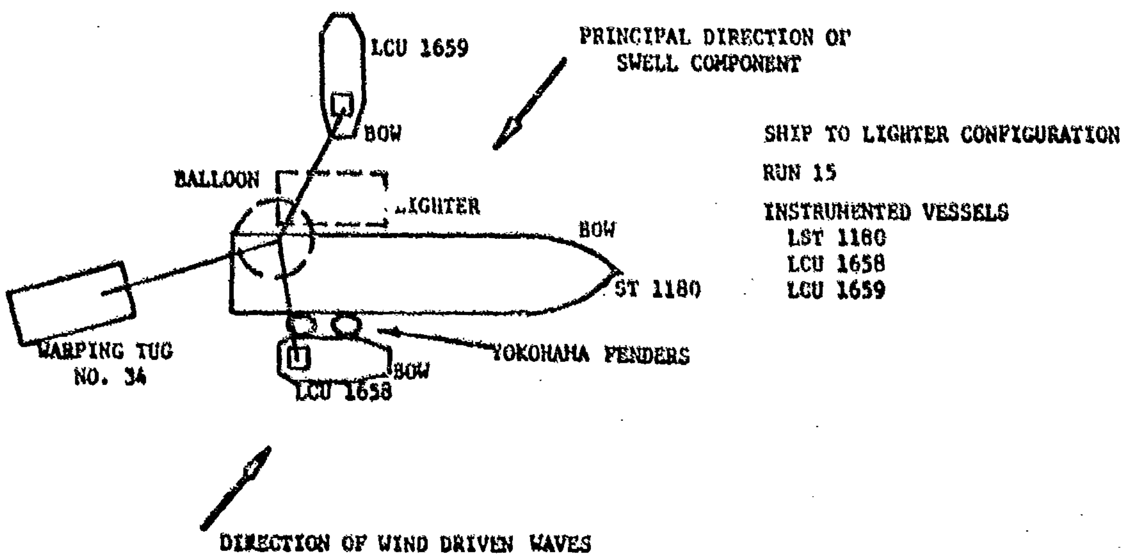


Figure 3 - Ship to Lighter Configurations in which the LST 1180 and LCUs 1658 and 1659 were Instrumented

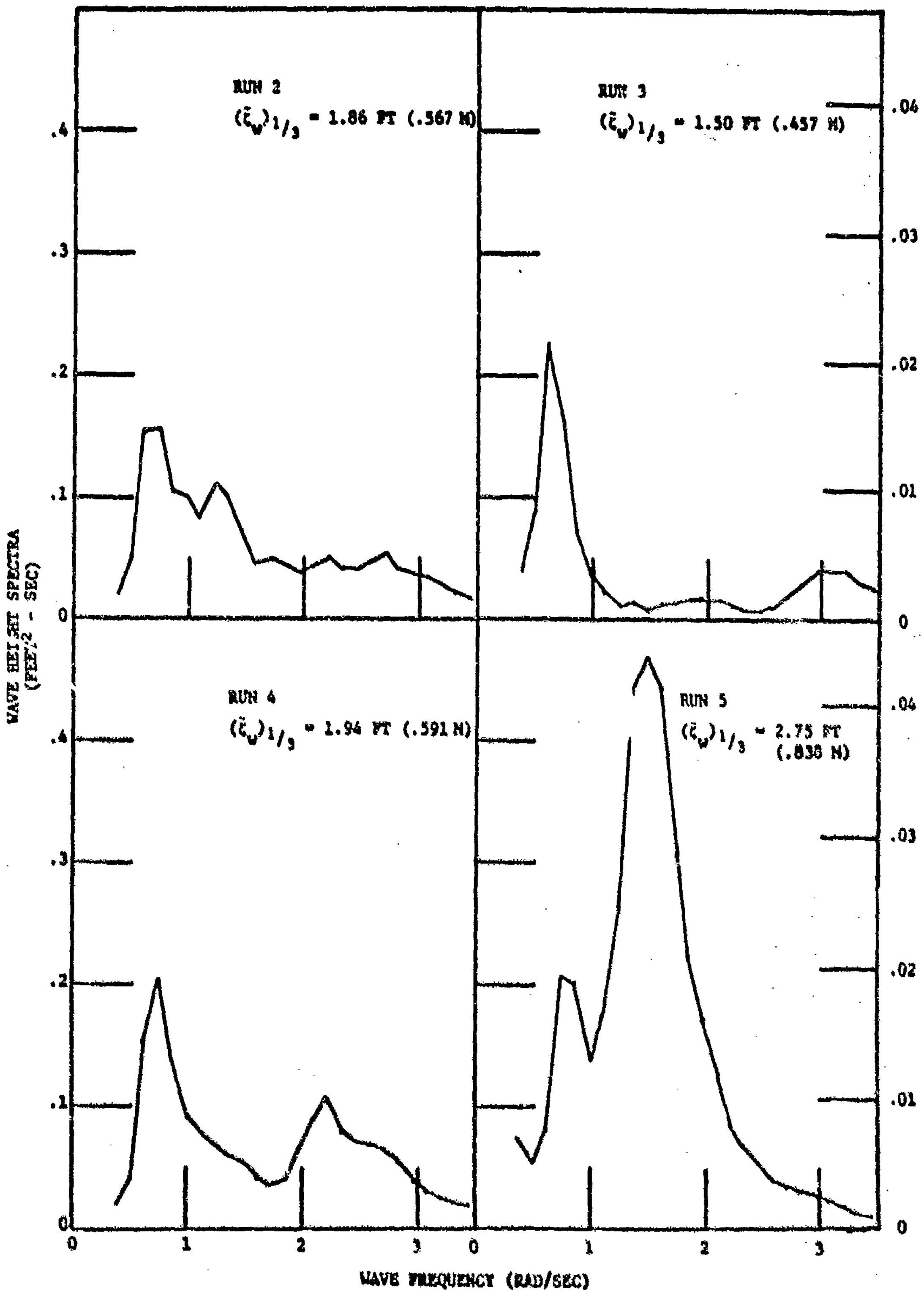


Figure 4 - Wave Height Spectra versus Wave Frequency as Recorded for Runs 2, 3, 4, 5 of the Balloon Transport System Evaluation

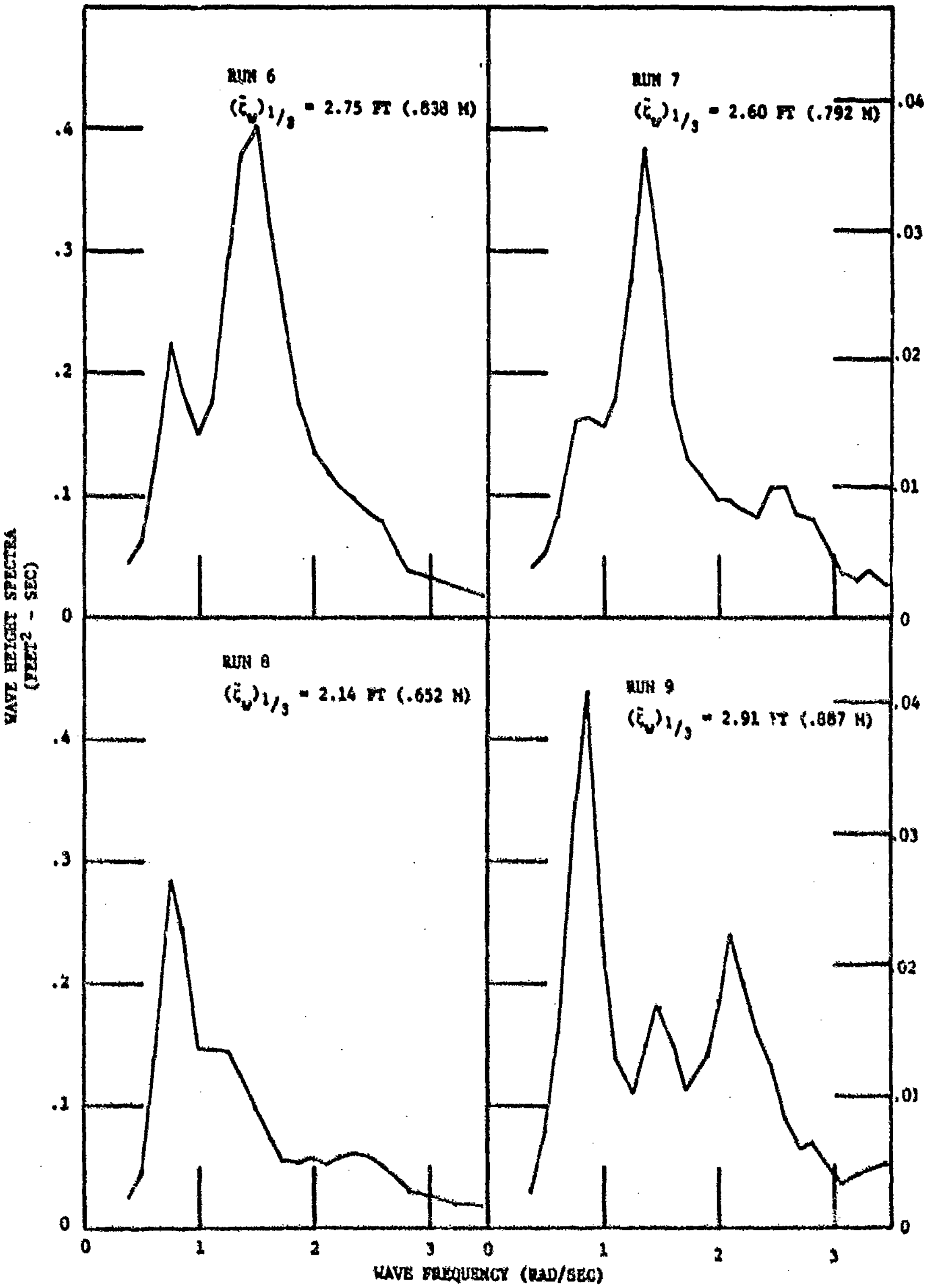


Figure 5 - Wave Height Spectra versus Wave Frequency as Recorded for Runs 6, 7, 8, 9 of the Balloon Transport System Evaluation

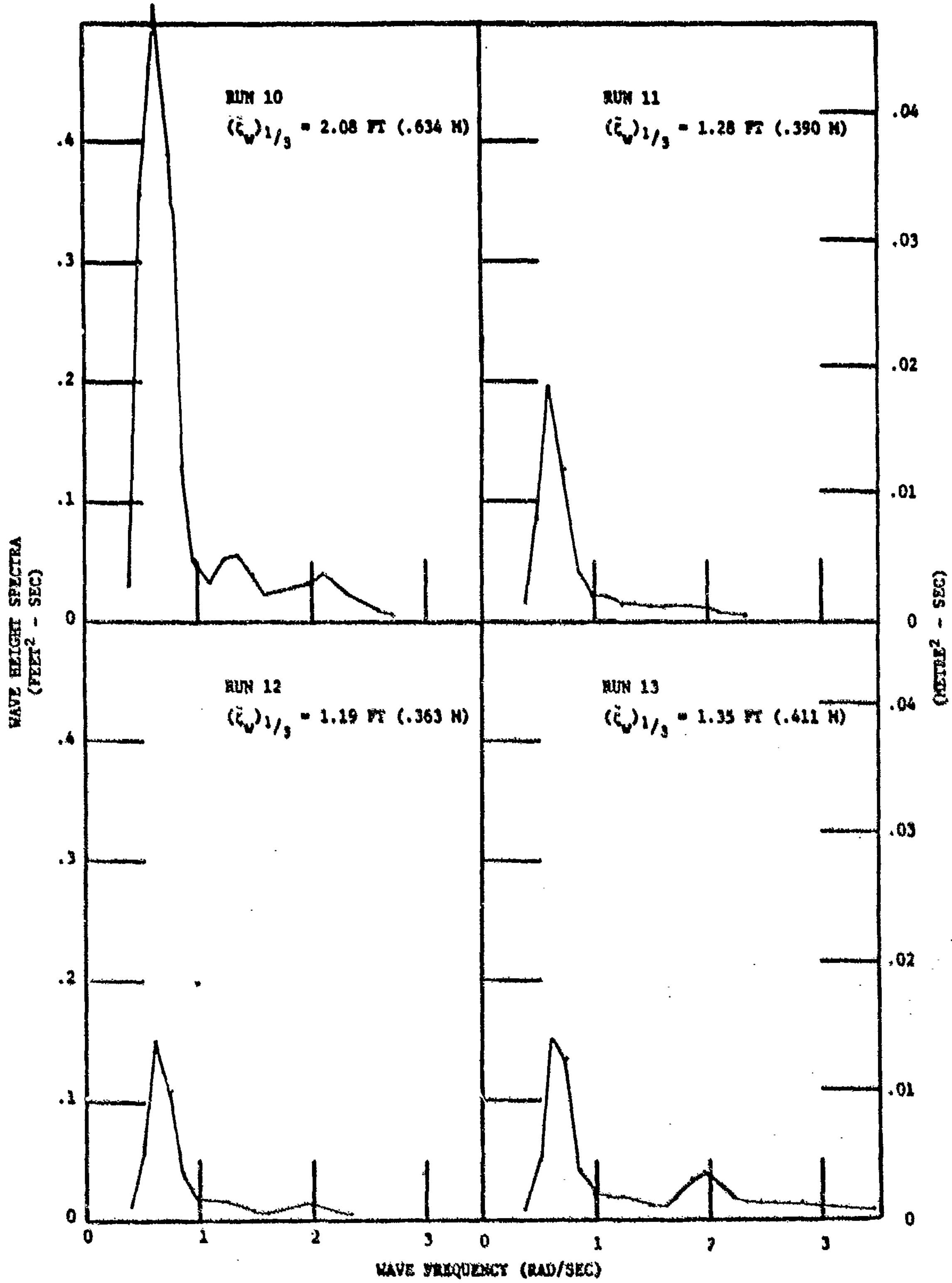


Figure 6 - Wave Height Spectra versus Wave Frequency as Recorded for Runs 10, 11, 12, 13 of the Balloon Transport System Evaluation

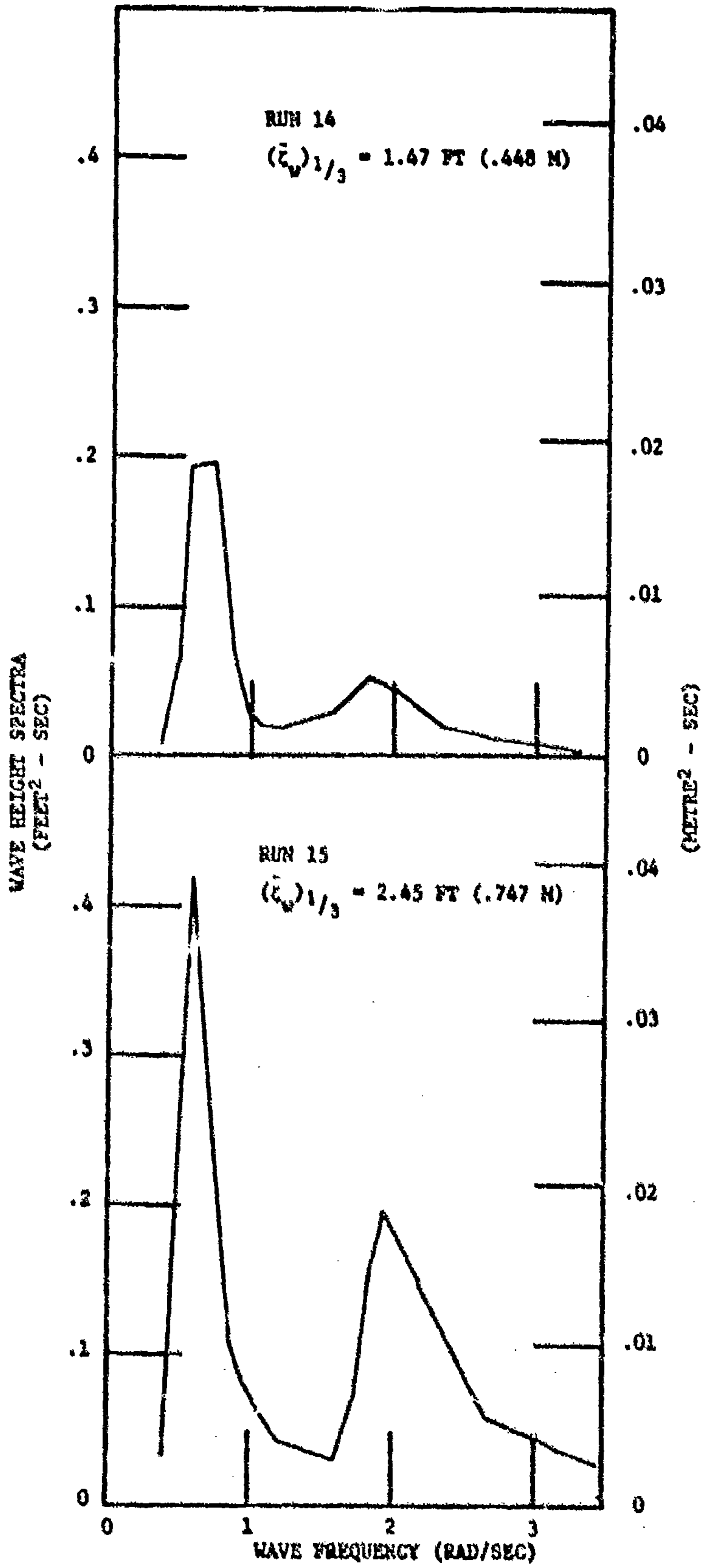


Figure 7 - Wave Height Spectra versus Wave Frequency as Recorded for Runs 14, 15 of the Balloon Transport System Evaluation